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SPACE STATION DATA HANDLING SYSTEM: EXPERIMENT CHARACTERISTICS STUDY REPORT

15 October 1970

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SPACE STATION DATA HANDLING SYSTEM:

EXPERIMENT CHARACTERISTICS

STUDY REPORT

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A-3085 (6/69)

ABSTRACT

This document specifies the software required to automate a candidate experiment for the NASA Manned Space Station. In addition, specifications are presented for ground-based simulation software to perform selected experiment operations. This work was performed under contract number NAS8-25471 for the Computation Laboratory of the George C. Marshall Space Flight Center, Huntsville, Alabama.

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SECTION 1. INTRODUCTION

This report is the first of two produced during Phase B of NASA study contract NAS8-25471, "Analysis of the Requirements for Computer Control and Data Processing Experiment Subsystems." Phase A was reported on in SDC document TM-(L)-HU-033/000/00, "Experiment Control and Data Processing Requirements Specification Report," dated 15 May 1970.

Because of the dual nature of the Phase B effort, the activity has been documented in two separate reports. This report specifies software for the X-ray Polarimeter Experiment (FPE 5.1). A second report, SDC document TM-(L)-HU-033/002/00, specifies data processing and control requirements for an additional Space Station experiment, X-ray Imaging Solar Telescope Experiment (FPE 5.3A). Both reports were prepared by the System Development Corporation's Huntsville Space Projects staff.

This specification establishes the requirements for performance and design of a set of computer programs to automate an X-ray Polarimeter Experiment. The experiment was defined during Phase A of this study. This specification is presented in three parts:

1) Functional specifications for software to automate the spaceborne experiment;
2) Detailed specifications for software to process primary experiment data in a ground-based environment; and
3) Detailed specifications for software to simulate the output of the primary experiment instruments.

SECTION 2. FUNCTIONAL SPECIFICATIONS FOR SPACEBORNE SOFTWARE

This part of the specification establishes the minimum capabilities of the on-board software to automate the X-ray Polarimeter Experiment (FPE 5.1). These specifications are based on software requirements presented in SDC document TM-(L)-HU-033/000/00.

To establish the operational environment for the spaceborne software, basic assumptions were made regarding the on-board computer capabilities. The experiment subsystem will include:

- A central processor capable of controlling multiple experiments.
- A large high-speed memory for program and current data storage.
- A very large bulk data store for temporary storage of experiment data.
- Massive write-only storage for permanent data records.
- A high-speed I/O.
- Experimenter terminals for both input and output.
- Interface capability with other subsystems such as Guidance, Navigation and Control, Communication, etc.

The purpose of this section is to provide the background to, and an understanding of, the software that will be simulated in a ground-based environment--the specifications of which are presented in Sections 3 and 4.

2.1 Major Module Requirements

Figure 2-1 presents the major modules required to automate the X-ray Polarimeter Experiment. Functional requirements for each module were presented in SDC document TM-(L)-HU-033/000/00. The requirements specified for the experiment, which would comprise a subset of the overall software requirements for a Space Station Experiment Subsystem, are summarized in Sections 2.1.1 through 2.1.13. of this report. In addition, in order to meet all the requirements of the experiment, it is necessary to utilize the resources of other on-board subsystems. Sections 2.2 through 2.4 present a discussion of the considerations involved in the X-ray Polarimeter Experiment's interaction with other subsystems, the Experiment Executive, and with the man-machine interface.

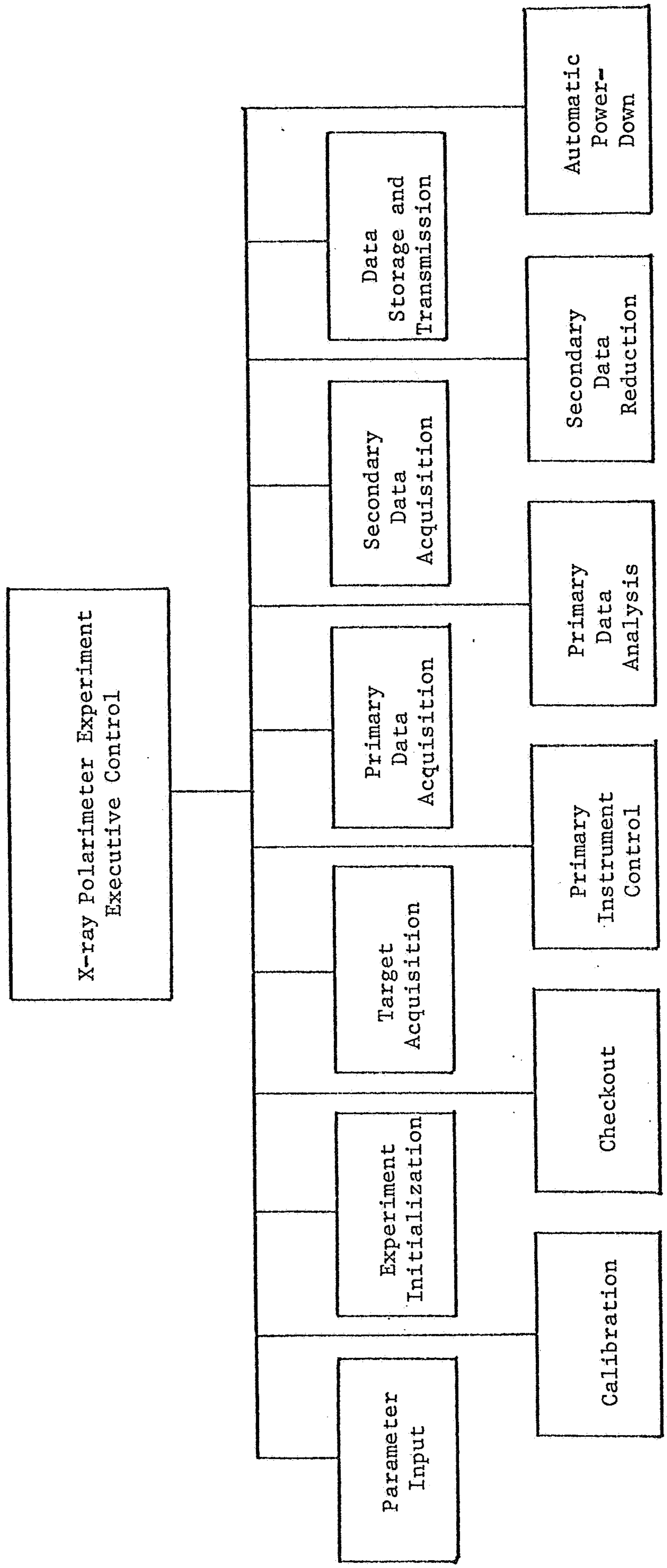


Figure 2-1. Software Design for X-ray Polarimeter Experiment

2.1.1 Module Name: Experiment Executive

2.1.1.1 Abstract: The Experiment Executive performs the overall control of the experiment and serves as the buffer between the operational experiment modules and the Experiment Subsystem.

2.1.1.2 Major Functions:

- Maintenance of experiment status information.
- Interface with the Experiment Subsystem Executive which performs scheduling, resource allocation and control functions for multiple experiments.
- Transfer of experiment data and parameters between the experiment modules.
- Calling experiment modules.
- Processing of interrupts.

2.1.2 Module Name: Parameter Input

2.1.2.1 Abstract: The Parameter Input module loads and edits all experiment parameters.

2.1.2.2 Major Functions:

- Input of experiment parameters including target list, secondary instrument list, etc.
- Editing of data for format and tolerances.
- Updating parameters by interactive communication with experimenter.
- Formatting and storing parameters in table format.

2.1.3 Module Name: Calibration

2.1.3.1 Abstract: The Calibration module performs the calibration of the astronomy module telemetry.

2.1.3.2 Major Functions:

- Initiation and control of the calibration function generator to step through the calibration sequence.
- Reading the output of the function generator.
- Comparison of the output of the function generator against a standard.
- Storing the calibration curve for measurement adjustments.
- Display of out-of-tolerance conditions.

2.1.4 Module Name: Experiment Initialization

2.1.4.1 Abstract: The Experiment Initialization module turns on and positions appropriate experiment apparatus prior to experiment execution.

2.1.4.2 Major Functions:

- Control of the automatic power-up procedure for the telescope, the polarimeter and associated instruments.
- Acquisition of equipment status information through the astronomy module telemetry system.
- Maintenance of the equipment status table to indicate the current status of all experiment apparatus.
- Control of the instrument turret to position the polarimeter at the focal point of the telescope.

2.1.5 Module Name: Checkout

2.1.5.1 Abstract: The Checkout module performs the automatic checkout of the experiment apparatus to determine its operational status.

2.1.5.2 Major Functions:

- Control of the checkout sequence.
- Direct digital control of the checkout instruments.
- Acquisition of checkout data.
- Comparison of checkout data values against prespecified standards.
- Display of out-of-tolerance measurements at the experimenter terminal.
- Initiation of corrective action to bring measurement within tolerance.
- Recheck specific measurements on demand and display results at the experimenter terminal.

2.1.6 Module Name: Target Acquisition

2.1.6.1 Abstract: The Target Acquisition module performs the automatic acquisition and tracking of celestial X-ray objects.

2.1.6.2 Major Functions:

- Transformation of standard celestial pointing coordinates--right ascension and declination--into space reference coordinates.
- Interface with the Guidance, Navigation and Control Subsystem to provide pointing and tracking commands to the astronomy module.
- Verification of target acquisition through the aspect/display system.
- Interaction with the on-board experimenter including the display of pointing information and processing of "fine tuning" commands to update the master target table.
- Calculation of a revised target sequence if the prespecified schedule cannot be followed due to anomalies or manual intervention.

2.1.7 Module Name: Primary Instrument Control

2.1.7.1 Abstract: The Primary Instrument Control module performs the direct digital control of all primary instruments.

2.1.7.2 Major Functions:

- Control the polarimeter table rotation by stepping the table to a desired position based on a preselected mode of operation.
- Open and close the telescope aperture disc to control the X-ray intensity at the telescope focal point.
- Reset all scalers, buffers and registers associated with the beam, data and anti-coincidence counters.
- Verify proper control through instrument feedback.

2.1.8 Module Name: Primary Data Acquisition

2.1.8.1 Abstract: The Primary Data Acquisition module acquires data from the polarimeter and associated equipment.

2.1.8.2 Major Functions:

- Monitoring the scaler overflow sensor to detect very high data rates.
- Read the output of data, beam and anti-coincidence scalers on a periodic and interrupt basis.
- Read the output of the pulsar mode counter every "η" milliseconds where η = buffer size.
- Identify and temporarily store all data for later analysis.

2.1.9 Module Name: Primary Data Analysis

2.1.9.1 Abstract: The Primary Data Analysis module performs the analysis and reduction of the primary polarimeter data.

2.1.9.2 Major Functions:

- Maintenance of cumulative totals of scaler data and exposure time for each object observed.
- Analysis of pulsar string data to detect pulsars and determine pulsation frequency.
- Storage and display of analyzed data.

2.1.10 Module Name: Secondary Data Acquisition

2.1.10.1 Abstract: The Secondary Data Acquisition module monitors the support instruments associated with the polarimeter, the telescope and the astronomy module.

2.1.10.2 Major Functions:

- Read the output of the secondary instruments through the astronomy module telemetry system.
- Comparison of data values against prespecified tolerances to establish GO/NOGO condition.
- Elimination of in-tolerance values to significantly reduce storage requirements.
- Generation of alarms to alert the on-board experimenter of out-of-tolerance measurements.
- Initiation of emergency routines to perform corrective action.

2.1.11 Module Name: Secondary Data Reduction

2.1.11.1 Abstract: The Secondary Data Reduction module reduces the volume of data generated by the secondary instruments.

2.1.11.2 Major Functions:

- Elimination of redundant data through use of polynomial predictor and interpolator algorithms.
- Reduction of data by format conversion.

2.1.12 Module Name: Data Storage and Transmission

2.1.12.1 Abstract: The Data Storage and Transmission module controls the storage and transmission of all experiment generated data.

2.1.12.2 Major Functions:

- Storage of primary data on retrievable mass storage.
- Storage of secondary data on write-only storage media for ground analysis.
- Formatting of primary data for transmission to the ground by the Communication Subsystem.

2.1.13 Module Name: Automatic Power-Down

2.1.13.1 Abstract: The Automatic Power-Down module performs the sequence of operations necessary to remove power from the telescope, polarimeter and associated equipment.

2.1.13.2 Major Functions:

- Control of the automatic power-down procedure for the telescope, the polarimeter and associated instruments.
- Acquisition of equipment status information through the astronomy module telemetry system.
- Updating the equipment status table to indicate the current status of the instruments.

2.2 Interface with Other Subsystems

Figure 2-2 presents the interface between the X-ray Polarimeter Experiment and other Space Station subsystems.

2.2.1 Guidance, Navigation and Control Subsystem Interface

Interface with the Guidance, Navigation and Control (GN&C) Subsystem is required to point the astronomy module housed telescope at targets of interest. Commands from the Experiment Subsystem to the GN&C Subsystem will include the position of the target of interest, the time to acquire the target and the length of

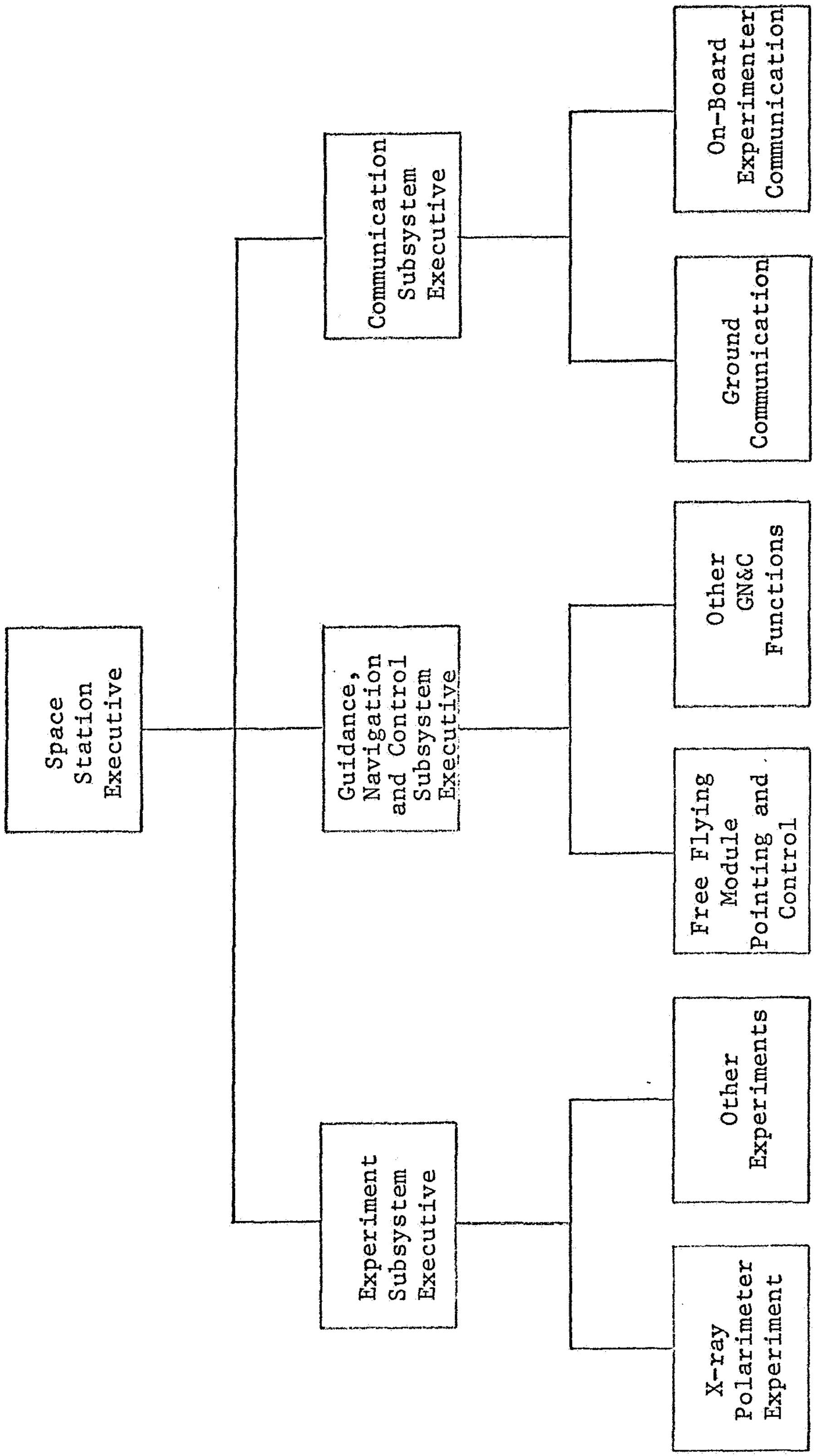


Figure 2-2. Interfacing Subsystems

time to track the target. Target position data will be transferred to the GN&C Subsystem in standard celestial coordinates--right ascension and declination. These coordinates will be transformed to the space reference coordinate system by the GN&C to provide initial pointing commands to the astronomy module. Notification of target acquisition will be transferred by the GN&C Subsystem to the Experiment Subsystem and the GN&C Subsystem will maintain the target for the time specified.

2.2.2 Communication Subsystem Interface

The Communication Subsystem controls and schedules all digital and analog data transmission between the various components of the Space Station complex. This includes up- and down-link transmission between the station and ground, inter-communication between station subsystems, and communication between the station and the free-flying modules.

Specific communication requirements between the X-ray Polarimeter Experiment and the Communications Subsystem includes:

- Transmission of commands to the telescope and the polarimeter.
- Transmission of primary polarimeter data and support instrument data from the free-flying module.
- On demand transmission of experiment data to the ground.

2.3 Executive Interface

Execution of multiple experiments in a time sharing mode of operation on a single computer system requires the systematic control of an executive system. Functions of the Experiment Subsystem Executive include:

- Scheduling program execution in a time-sharing environment. Due to the real-time nature of this experiment, and most other space-borne experiments, the scheduling of the various experiment tasks is critical. The scheduling algorithm of the Experiment Subsystem Executive must base program execution on considerations other than the standard factors of priority, congruency and data transfer delay. The primary consideration is time. The majority of the experiment tasks are a function of time, e.g., power must be applied to component B after "η" seconds of application of power to component A. This requires a look-ahead scheduling algorithm within the Experiment Subsystem Executive which is capable of scheduling all experiments and experiment tasks within a framework of time constraints. Therefore, the executive must have access to each experiment's scheduling parameters to coordinate the execution of the X-ray Polarimeter Experiment modules with other experiment modules.

- Program and data swapping. Due to limitations in main storage capacity, it is likely that the programs and/or data will have to be swapped out of main storage to allow execution of other experiments. As in the case of the schedule control function of the executive, the "swapper" must have knowledge of experiment timing constraints, i.e., program or data segments cannot be swapped out of main memory if the time required to perform the transfer is greater than the time which will elapse before the program or data segment is needed.

- Processing of external interrupts. Since the nature of experimentation suggests that unexpected events will occur, or that expected events will occur at unexpected times, it is necessary to make provisions for such occurrences without constant monitoring. Such a condition is indicated by an external interrupt which is processed by the Interrupt Handler program of the Experiment Subsystem Executive. It is the function of the Interrupt Handler program to initiate the calling up of the required programs to handle the situation which generated the interrupt. External interrupts are generated by the X-ray polarimeter to indicate an overflow of one or more of the data, beam or anti-coincidence counters.

- Other executive functions that must be considered but which do not interact directly with the X-ray Polarimeter Experiment include (1) the allocation of resources to operating programs, (2) maintenance of control tables, data catalogues, program catalogues and priority lists and (3) bookkeeping functions.

2.4 Man-Machine Interface

The nature of experimentation suggests a changing environment and the occurrence of unexpected events. If this were not the case, experimenters would remain earth-bound and only unmanned spacecraft would be orbited to conduct experiments in an predetermined, automatic mode. The value of the on-board experimenter is his ability to react, to perceive and to modify. To perform these functions, the on-board experimenter must interact with his experiment. Since the experiments are designed to be controlled and monitored by computer, the logical extension is to provide a direct means of interaction utilizing the available computer facilities--a man-machine interface.

2.4.1 Hardware

The minimum man-machine interface hardware required for the X-ray Polarimeter consists of a keyboard input device and a CRT.

The keyboard input device is used primarily for interactive dialog between the on-board experimenter and the computer system. On-line changes can be made to the experiment schedule, historical data can be retrieved, pointing and tracking commands can be input on a real-time basis to perform unscheduled observations, emergency routines can be initiated, etc., all under control of the interactive dialog system.

The CRT serves primarily to display primary experiment data in graphical format. Polar coordinate plots of the polarization of X-ray sources and frequency plots of pulsation activity are displayed on the CRT. The CRT is also used as the output device in interactive dialog between the on-board experimenter and the computer; it is used to display out-of-tolerance measurements during checkout, calibration and monitoring operations; and it serves as the display device for the aspect system to verify target acquisition.

2.4.2 Language

An interactive language should serve as a bridge between the on-board experimenter and the X-ray Polarimeter Experiment. This language should assist the experimenter in initiating experiment tasks, in controlling and monitoring his experiment instruments, in performing updates to his experiment data base, in acquiring experiment status information, in retrieving historical experiment data and in analyzing his data. These functions are common to most all experiments; therefore, a universal experimenter's interactive language should be considered. Many of the required elements of such a language are currently in wide use in existing interactive data management and management information systems.

Examples of language elements of particular utility to the on-board experimenter in controlling and monitoring the X-ray Polarimeter Experiment include:

- SET - To set a discrete or analog value
- RESET - To reset a discrete or analog value
- POINT - To point a data collecting device at a specified area of interest
- TRACK - To maintain a data collecting device on an area of interest for a specified period
- STEP - To move a servo-driven device to a specified position at a given rate
- ACQUIRE - To read the output of a digital, discrete or analog device
- UPDATE - To modify experiment control parameters
- PRINT - To output experiment data in tabular form
- PLOT - To output experiment data in graphic form
- CALL - To call preprogrammed statistical, mathematical, manipulative, etc., packages to perform impromptu data analysis

2.4.3 Output

The primary data from the X-ray Polarimeter Experiment is presented in graphic form on board the Space Station. The graphic format provides a quick observation capability and allows visual comparisons to be made without making a point-by-point analysis. A plot of the pulsation frequency is presented at the end of the first 10 seconds of continuous observation. A polar coordinate plot of the polarization of the X-ray source is presented at the end of an observation sequence.

The format of secondary or support data primarily will be tables and listings. Lists of out-of-tolerance measurements will be produced by the Calibration, Checkout and Secondary Data Acquisition modules.

SECTION 3. SPECIFICATIONS FOR SIMULATED SOFTWARE

In order to test some of the concepts of spaceborne software specified in Section 2 for the X-ray Polarimeter Experiment, selected modules are specified in detail for implementation on a ground-based computer. Due to the type of equipment available for simulation purposes, only those modules which could be realistically simulated in such an environment were selected. The selected modules deal primarily with the processing of data from the prime experiment instruments rather than with the direct digital control of instruments required in such operations as calibration, checkout, target acquisition, etc.

These specifications assume the following computer capabilities:

- A CPU with a minimum of 32K core
- Floating point arithmetic
- Card input for experiment control parameters
- Tape input for simulated X-ray polarimeter data (2 tapes)
- Off-line display of graphic data (SC-4020)

3.1 Program Tables

Input, output and working tables for the simulated X-ray Polarimeter Experiment program are presented in the following table.

Table Name	Size (words)	Description
EVART(A,B)	10,12	Table EVART contains the source identification data input prior to experiment simulation. Up to 10 sources may be run (A) and 10 parameters given for each source as follows: 1-3 Identification 4 Right Ascension (hours) 5 Right ascension (minutes)

Table Name	Size (words)	Description
		6 Declination (degrees)
		7 Declination (minutes)
		8 Observation time
		9 Beginning table position
		10 Ending table position
		11 Table step size
		12 Number of table positions
NS	1	Number of sources
NP	1	Plot flag
SPDC(A)	36	Working storage table containing the sum of the polarimeter counts at each table position A
POLDT(A,B,C)	(10,36,16)	Cumulative polarimeter data for up to 10 sources (A), 36 table positions (B) and 16 measurements (C)
PULDT(A)	5000	Contains 5 seconds of observation time at 1000 per second
PA(A)	4096	Contains power amplitudes of pulsar data

3.2 Module Specifications

Figure 3-1 presents the general flow of the simulated X-ray Polarimeter Experiment. Major routines include:

- Parameter Initialization
- Polarimeter Data Acquisition
- Polarimeter Data Display
- Pulsar Data Acquisition
- Pulsar Data Analysis
- Pulsar Data Display

Each major routine is described in Sections 3.2.1 through 3.2.6

3.2.1 Parameter Initialization Routine

The Parameter Initialization routine inputs experiment control variables and initializes all arrays and tables.

3.2.1.1 Input: The following variables are input at the beginning of the run.

1. Number of sources to be observed.
2. For each source
    a. identification (any string of up to 18 characters)
    b. observation time at each table position (seconds)
    c. right ascension (hours, minutes)
    d. declination (degrees, minutes)
    e. beginning table position (degrees)
    f. ending table position (degrees)
    g. table step size (degrees)
3. Plot flag (1 = plot 8 levels of intensity and cumulative, 0 = plot cumulative only).

A maximum of 10 sources can be input for any one run. Input will be by cards in NAMELIST format.

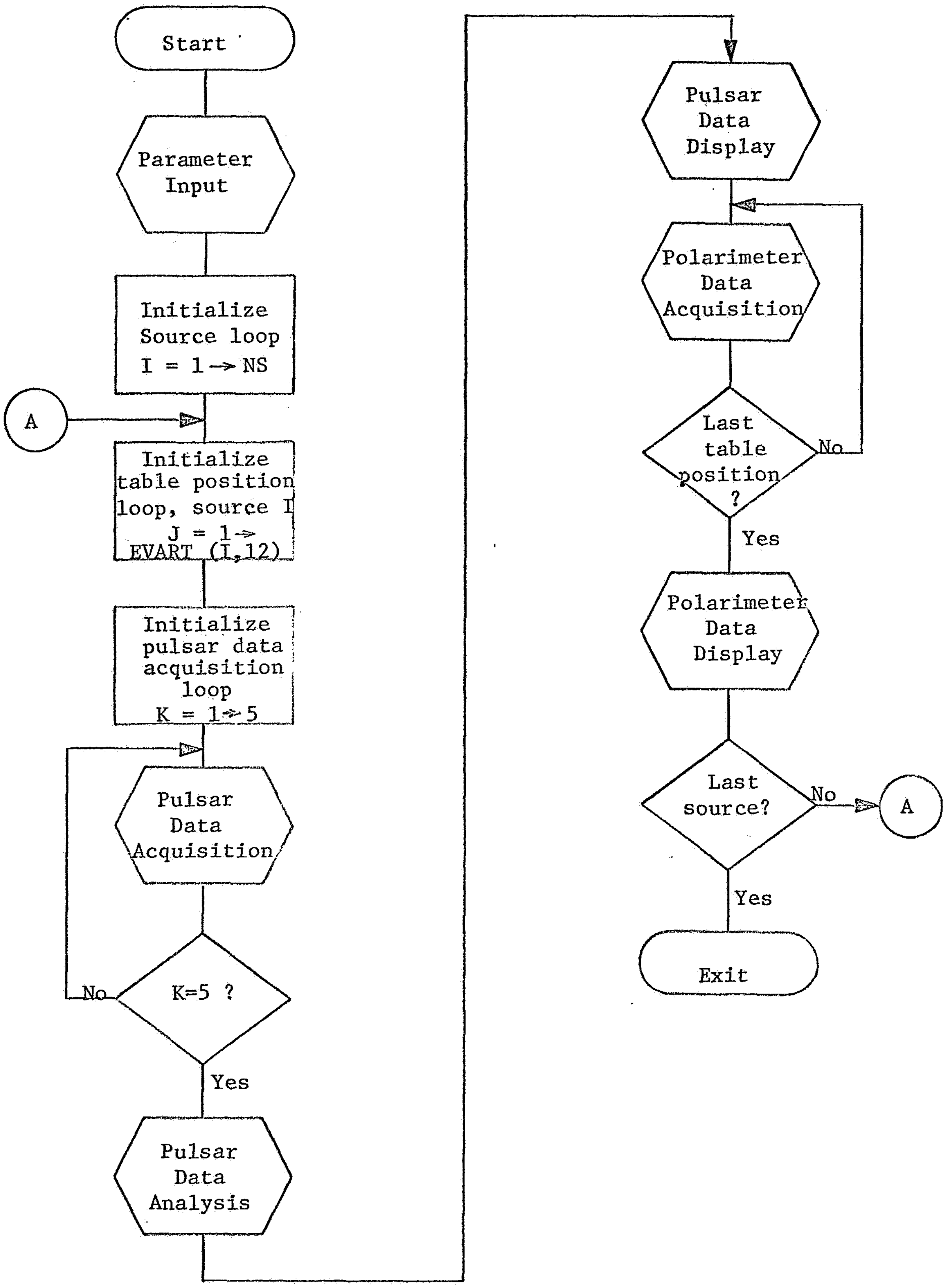


Figure 3-1. General Flow for Simulated Experiment

3.2.1.2 Processing: The following tables must be cleared prior to program execution:

POLDT

PULDT

Input values for each X-ray source are stored in array EVART. The number of table positions is calculated as

$$\text{EVART } (n,\ 12) = \frac{\text{End table position - Begin table position}}{\text{Table step size}}$$

3.2.1.3 Output: All variables are stored in the Experiment Variable Table (EVART). See Figure 3-2.

3.2.2 Polarimeter Data Acquisition Routine

The Polarimeter Data Acquisition Routine acquires polarimeter data from the simulated Polarimeter Data tape (see Section 4), edits the data and maintains cumulative totals of all scaler outputs.

3.2.2.1 Input: Input to this routine consists of the simulated polarimeter data. Data counts and beam counts are subdivided into 8 levels of intensity, making the total number of scaler inputs = 16.

3.2.2.2 Processing: Each input data value is edited to strip it of extraneous data and the remaining value is added to the cumulative total in array POLDT. See flow diagram, Figure 3-3.

3.2.2.3 Output: Output will be the cumulative scaler data in the Polarimeter Data Table (POLDT). See Figure 3-4.

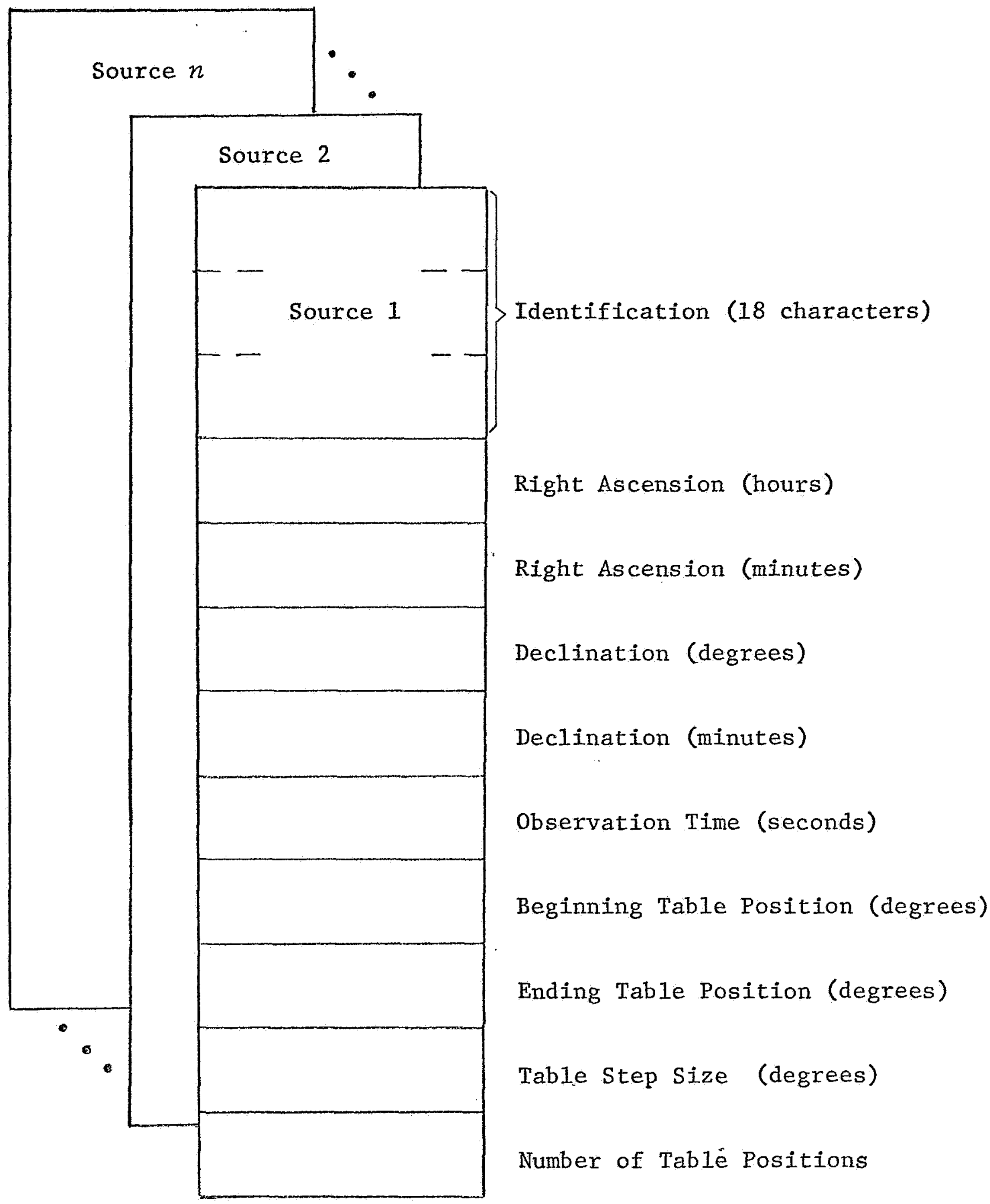


Figure 3-2. Experiment Variable Table (EVART)

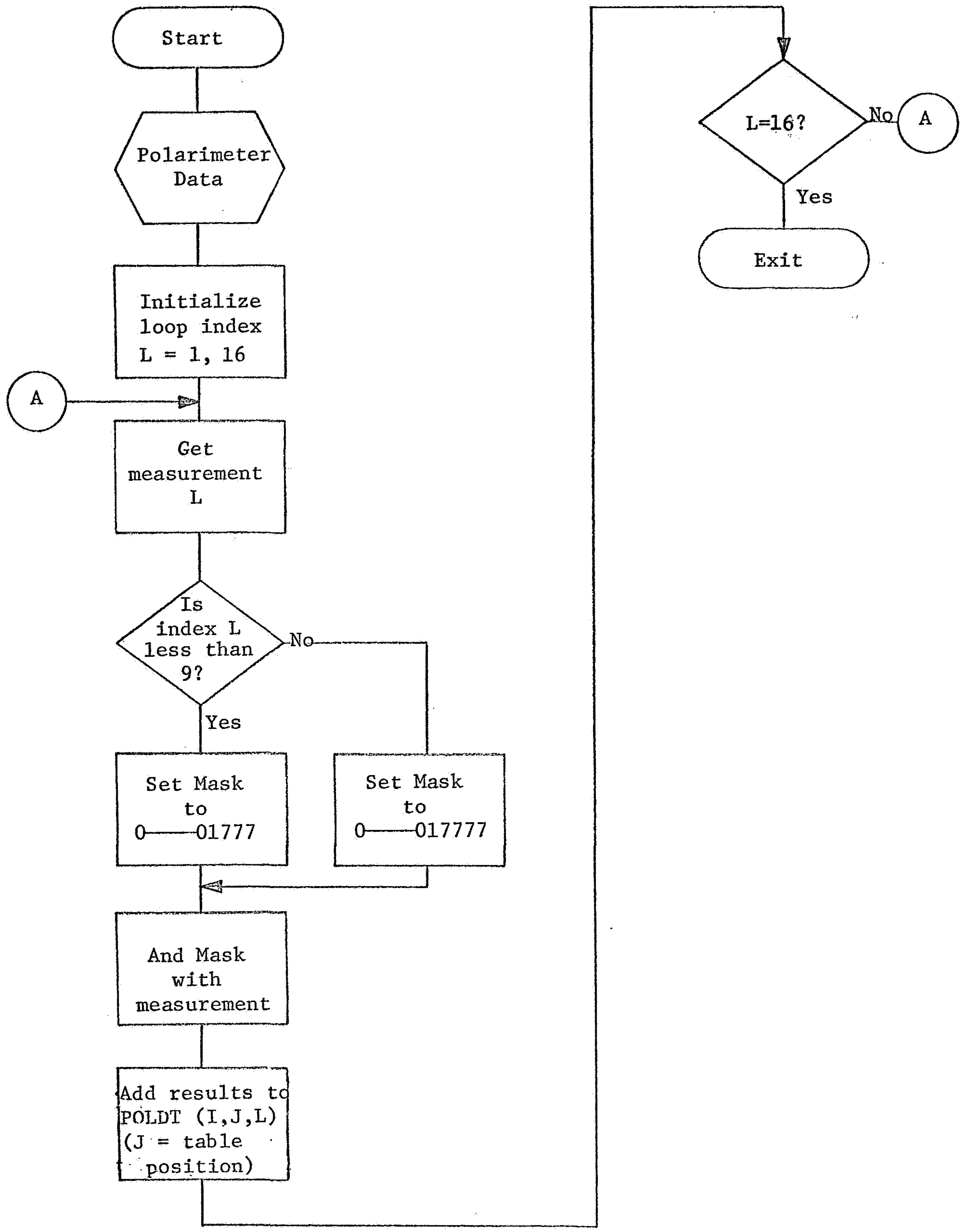


Figure 3-3. Polarimeter Data Acquisition Routine

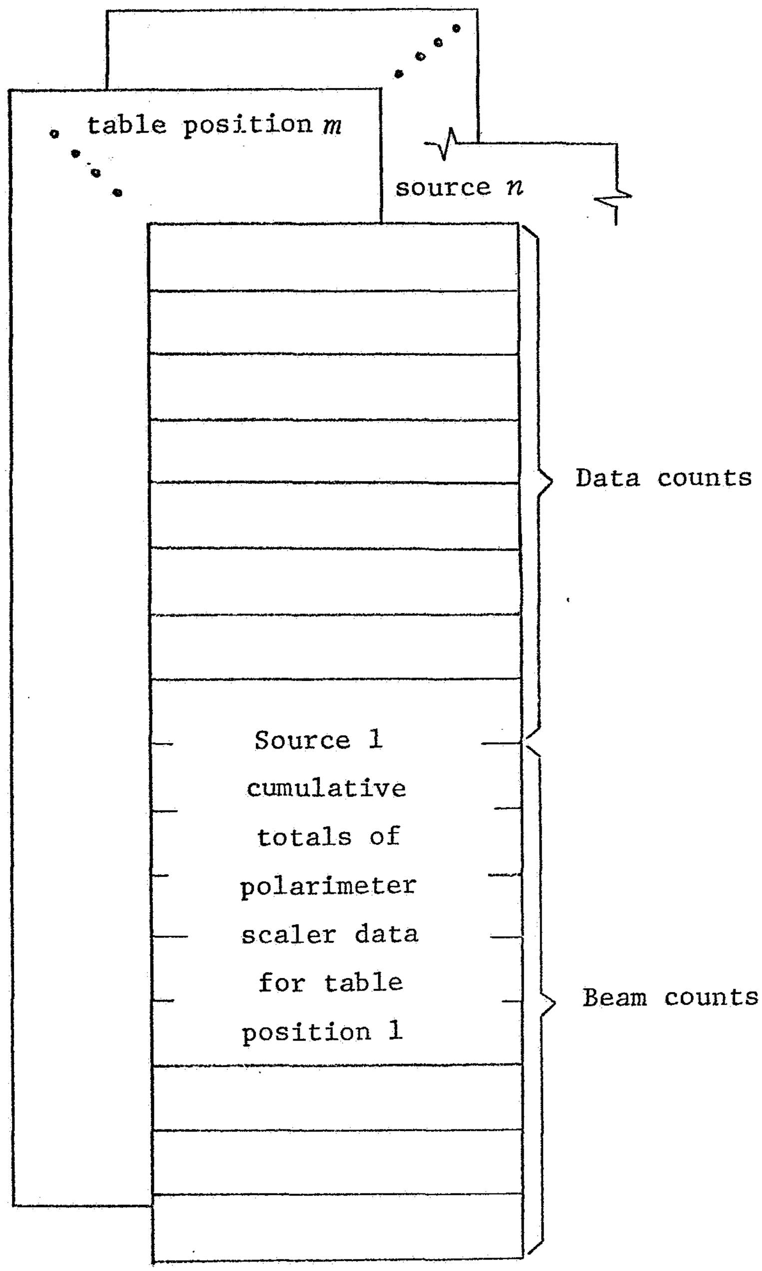


Figure 3-4. Polarimeter Data Table (POLDT)

3.2.3 Polarimeter Data Display Routine

The Polarimeter Data Display routine produces graphic plots of the polarization of the X-ray polarimeter data.

3.2.3.1 Input: Input to this routine is the Polarimeter Data Table (POLDT). See Figure 3-4.

3.2.2.2 Processing: Required processing includes the summation of the 8 levels of intensity to produce a plot of total polarization, the calculation of the degree of polarization and interpolation to determine the angle of maximum polarization. See Figure 3-5.

3.2.3.3 Output: Polarization data is presented in graphic form. If flag NP = 0, only 1 plot is produced for the sum of all 8 levels of intensity. If flag NP = 1, a plot is produced for each of the 8 levels of intensity for which there is data present, in addition to the plot of the summed data. The legend for each plot will include the X-ray source identification, degree of polarization, and angle of maximum polarization. See Figure 3-6.

3.2.4 Pulsar Data Acquisition Routine

The Pulsar Data Acquisition Routine acquires pulsar data from the Simulated Pulsar Data tape (see Section 4) and edits the data for future analysis.

3.2.4.1 Input: Input to this routine consists of the simulated string data from the pulsar mode counter. Data is in binary form where one bit represents 1 millisecond of X-ray observation. If the pulsar mode counter recorded one or more X-ray photon hits during a 1 millisecond time period, a "1" is recorded in the associated bit position of the bit string. If no hits are recorded, a "0" is placed in the bit string.

3.2.4.2 Processing: The input string data is edited and converted to floating point format to facilitate later analysis.

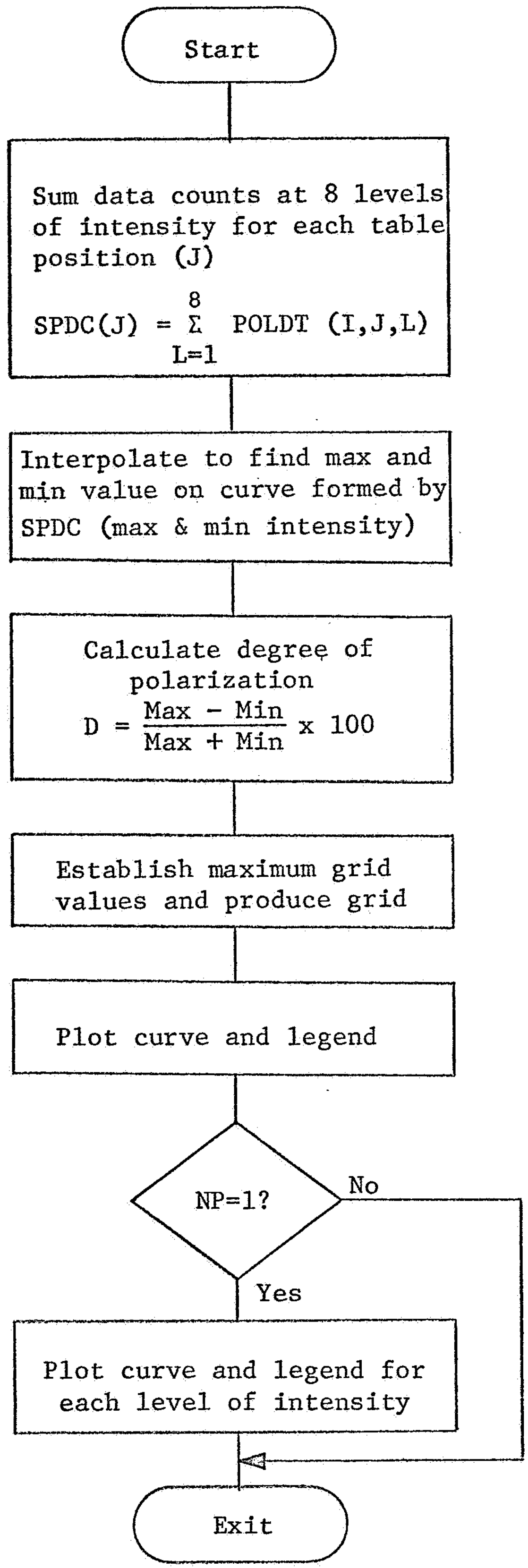
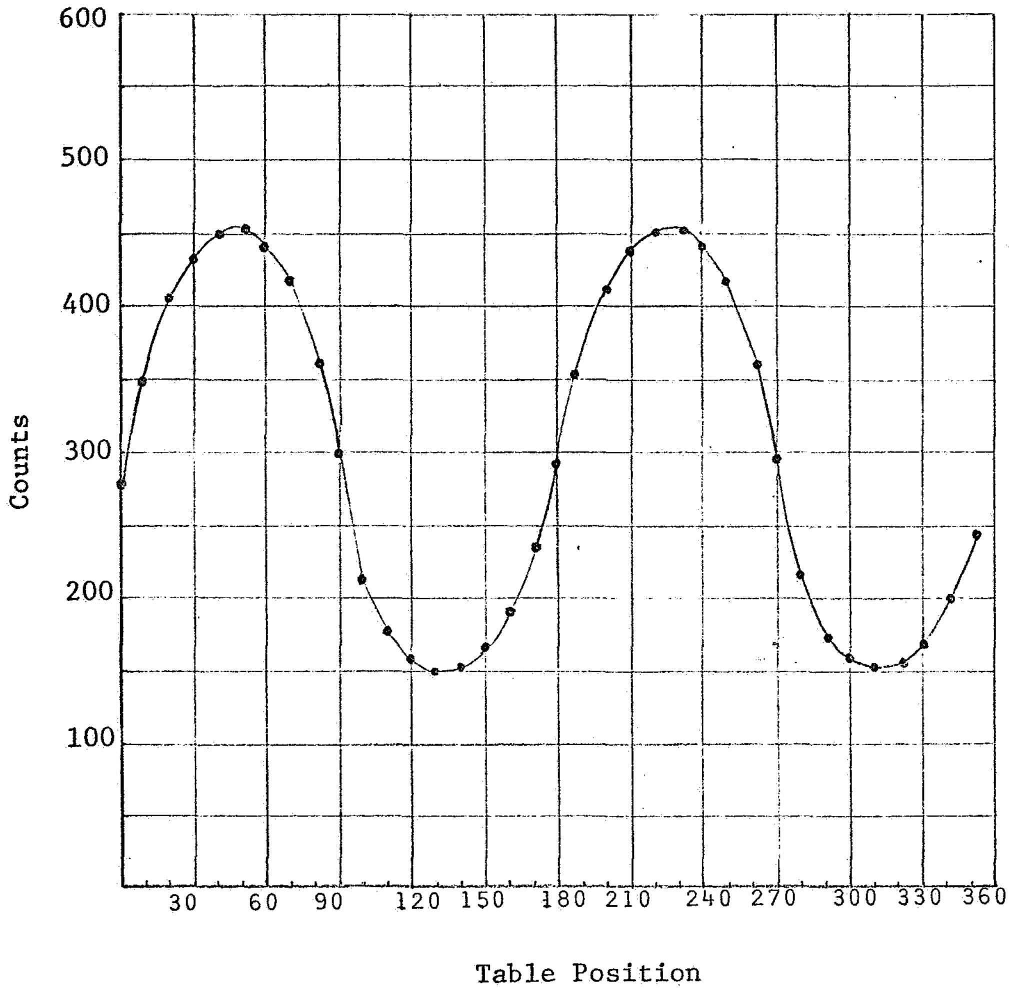


Figure 3-5. Polarimeter Data Display Routine



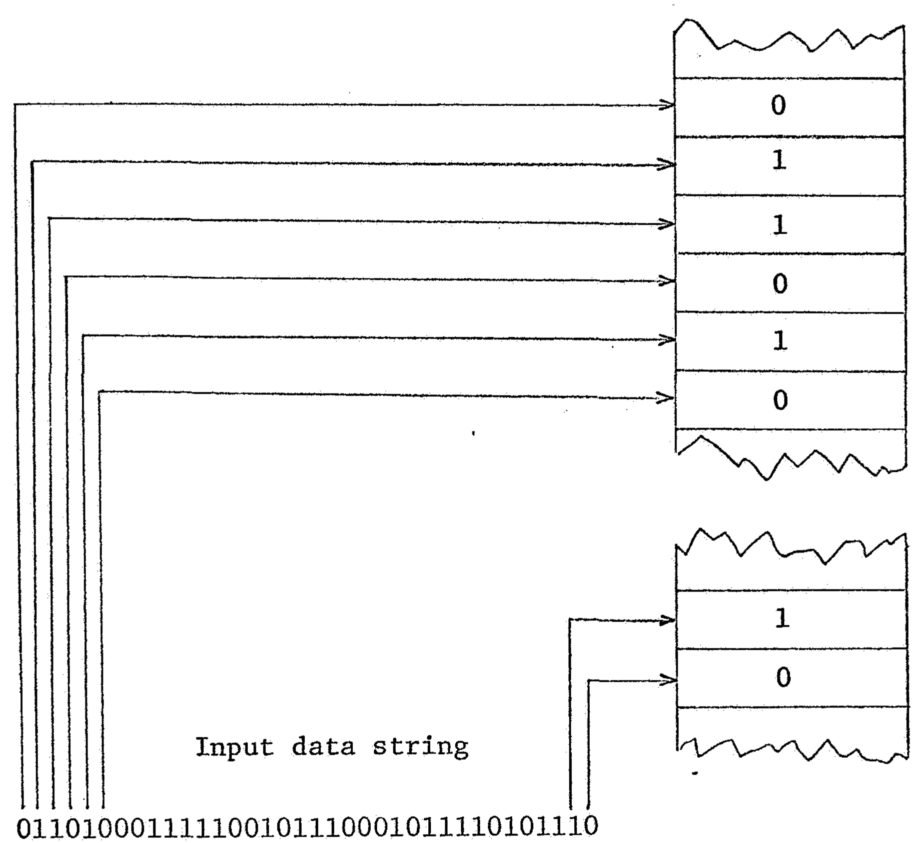
Source: SRK-90

Degree of polarization: 50.41%

Angle of maximum polarization: 46.3°

Figure 3-6. Example of Polarization Plot

3.2.4.3 Output: The string data is stored sequentially in the Pulsar Data Table (PULDT). To facilitate later on-line analysis of this data, the table format is 1 word per 1 bit of input as follows:



Total length of the Pulsar Data Table is 5,000 words.

3.2.5 Pulsar Data Analysis Routine

The Pulsar Data Analysis Routine detects X-ray pulsations and determines the approximate pulsation period. This routine is executed at the end of the first 5 seconds of observation.

3.2.5.1 Input: Input to this routine is the edited pulsar mode counter data in the Pulsar Data Table (PULDT).

3.2.5.2 Processing: The method used to detect pulsars and to estimate their fundamental frequency is an application of a Cooley-Tukey type Fast Fourier Transform (FFT) to obtain a power spectrum of the detected x-radiation. The pulse train of unity amplitude serves as the input to the FFT which produces cosine and sine amplitude coefficients:

$$A_r = \frac{2}{N} \sum_{k=0}^{N-1} X_k \; (\cos 2\pi rk/N) \qquad r = 0, 1, \ldots, N-1$$

$$B_r = \frac{2}{N} \sum_{k=0}^{N-1} X_k \; (\sin 2\pi rk/N) \qquad r = 0, 1, \ldots, N-1$$

where A_r and B_r are the $r^{\underline{th}}$ coefficients, X_k denotes the k<u>th</u> sample of the time series of N samples.

From the cosine and sine amplitude coefficients, a set of power amplitudes is computed as

$$PA_r = \frac{(A_r + jB_r)(A_r - jB_r)}{T}$$

where T is the number of time increments in the sample and $j = \sqrt{-1}$

The spectrum of power amplitudes is sorted to isolate the frequencies at which the amplitudes are the highest. The 10 highest amplitudes are summed and averaged and if the resulting value is greater than "p"% of the average of the sum of all amplitudes, the source is considered a pulsar. (The value of "p" must be determined empirically but will likely be in excess of 50%.) The frequency at which the power amplitude is the greatest is the fundamental frequency of the X-ray source. See Figure 3-7.

3.2.5.3 Output: The output of this routine is a flag to indicate whether or not the source is identified as a pulsar. If the source is a pulsar, table PA will contain the period and amplitude of the predominate frequencies of the X-ray source.

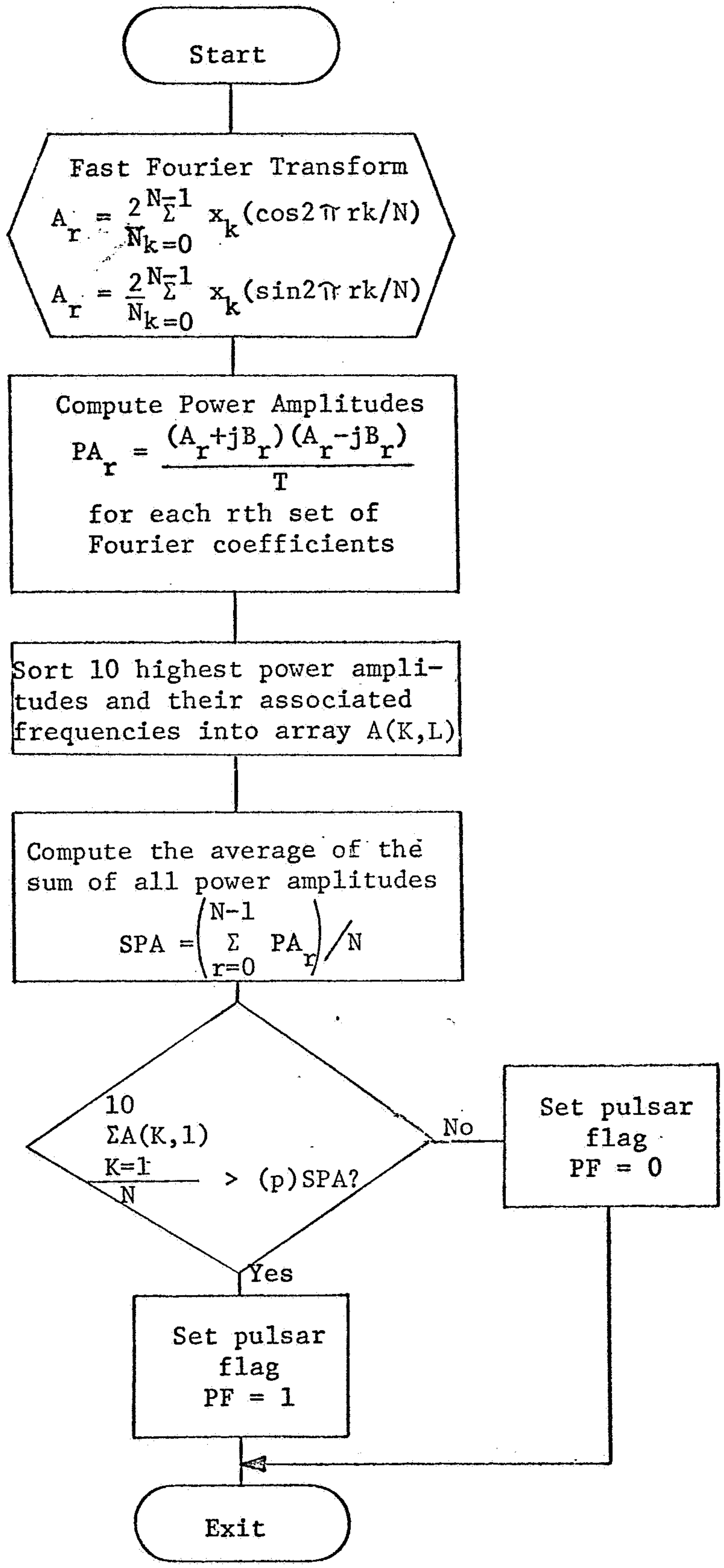


Figure 3-7. Flow of Pulsar Data Analysis Routine

3.2.6 Pulsar Data Display Routine

The Pulsar Data Display Routine presents the analyzed pulsar data in graphic form.

3.2.6.1 Input: Input to this routine is table PA, the set of power amplitudes produced by the Pulsar Data Analysis Routine.

3.2.6.2 Processing: See Figure 3-8.

3.2.6.3 Output: For each frequency within the spectrum, the power amplitude is plotted. The source identification and the dominant frequency is printed as the legend to the graph. See Figure 3-9.

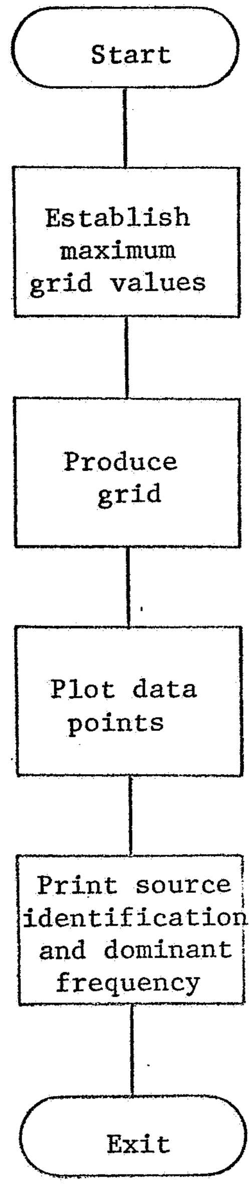
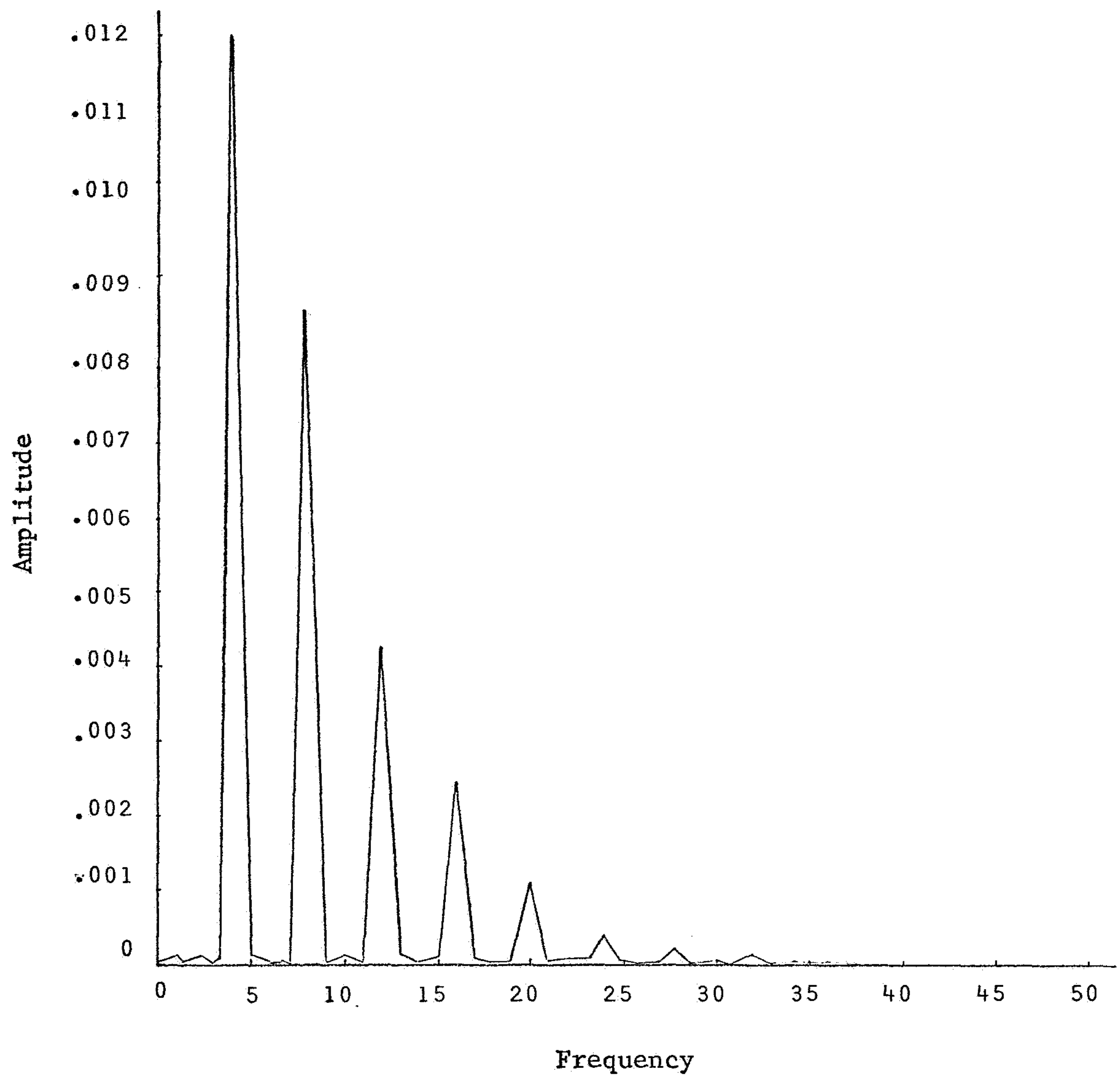


Figure 3-8. Flow of Pulsar Data Display Routine



Source: SRK-90

Dominant frequency: 4 cycles per second

Figure 3-9. Example of Pulsar Data Plot

SECTION 4. DATA GENERATION PROGRAM SPECIFICATIONS

This section presents detailed specifications for a data generator to simulate the output of the polarimeter and the pulsar mode counter of the X-ray Polarimeter Experiment. The output of this program serves as the input to the simulated experiment program specified in Section 3.

4.1 Program Tables

Input, output and working tables for the Data Generator Program are presented in the following table:

Table Name	Size (words)	Description
NAME(A)	3	X-ray source identification - any characters up to 18
ITIME	1	Observation time at each table position (seconds)
STEP	1	Polarimeter step size (degrees)
BEGIN	1	Beginning polarimeter table position (degrees)
END	1	Ending polarimeter table position (degrees)
AMAX	1	Angle of maximum polarization (degrees)
DATAM	1	Data counts in plane of maximum polarization (average data counts per second)
DATAP	1	Data counts in plane perpendicular to plane of maximum polarization (average data counts per second)
TOTI	1	Total intensity of the X-ray source (average data and beam counts per second)
RD	1	Desired average deviation of polarimeter data from true sine wave (percentage)
FREQ	1	Pulsation frequency of X-ray source (pulses per second)

Table Name	Size (words)	Description
AMP	1	Pulsation peak amplitude
PHS	8	Pulse height spread (percentages)
DATA(A)	8	Computed data counts for 8 pulse heights
BEAM(A)	8	Computed beam counts for 8 pulse heights
N(A)	1000	Temporary storage area for 1 second of pulsar data
NOUT(A)	28	One second of pulsar data packed 36 bits/word.

4.2 Input

The following variables are input at the beginning of program execution:

NAME	AMAX	FREQ
ITIME	DATAM	AMP
STEP	DATAP	PHS
BEGIN	TOTI	
END	RD	

See Section 4.1 for description of each input item.

4.3 Processing

Processing functions to generate the polarimeter and pulsar data is presented in figure 4-1. Sections 4.3.1 and 4.3.2 present the equations utilized in the simulation process.

4.3.1 Polarimeter Data Generation

Polarimeter data generated by the Data Generator is a sinusoidal function of the angle of polarization. Data counts for 1 second of observation are calculated as:

$$\text{COUNT} = C + (\sin 2\ A)\ D$$

where C is the average number of counts per second: i.e.

$$C = \text{DATAP} + \frac{\text{DATAM} - \text{DATAP}}{2}$$

A is the adjusted table position; i.e.

$$A = \frac{\text{ALPHA} + 45° - \text{AMAX}}{57.296}$$

where ALPHA is the table position for which data is being generated and 57.296 is the conversion factor for degrees to radians.

D is the maximum deviation from the average counts per second; i.e.,

$$D = \frac{\text{DATAM} - \text{DATAP}}{2}$$

The counts for each second of observation are then adjusted by Monte Carlo methods to provide a degree of randomness as might be experienced in an actual experiment environment; i.e.,

$$T = \text{COUNT } [(\text{RN})(2)(\text{RD}) + 1 - \text{RD}]$$

where RN is a uniformly distributed random number between 0. and 1.0 and RD is the maximum random deviation desired.

The adjusted counts are then distributed to eight pulse height bins based on pulse height spread expressed as a percentage of the total counts; i.e.,

$$\text{DATA}_i = T \ (\text{PHS}_i)$$

This process is repeated for each second of observation and the resulting adjusted data counts for each pulse height level are summed for the length of X-ray observation specified by input variable ITIME.

Beam counts are calculated as

$$B = (\text{TOTI} - T)[(\text{RN})(2)(\text{RD}) + 1 - \text{RD}]$$

where TOTI is the total intensity.

The beam counts are distributed and summed the same as the data counts.

4.3.2 Pulsar Data Generation

Pulsar data from the Pulsar Mode Counter is in bit string format where a "1" indicates an X-ray photon hit and a "0" indicates no hit during each millisecond of observation. Pulsar data is generated as a sinusoidal function of time; i.e.,

$$F = \frac{AMP}{2} \sin\left[\frac{2\pi(i - 1)}{P}\right] + RN$$

where AMP is a variable peak amplitude, i indicates the ith millisecond of observation during period P where

$$P = (1./FREQ)\ 1000.$$

and RN is a uniformly distributed random number between 0. and 1.0.

F is compared against a threshold, TH, where

$$TH = 1. - (TOTI/1000.)$$

for $F \geq TH$, $N_i = 1$ and for $F < TH$, $N_i = 0$

4.4 Output

Magnetic tape is the output media used for the polarimeter and pulsar data.

Record format for the Simulated Polarimeter Data tape is presented in Figures 4.2. One record is output for each table position. One file consists of the data for one X-ray source.

The format of the Simulated Pulsar Data tape is presented in Figure 4.3. Each record represents one second of X-ray observation and each file represents one X-ray source.

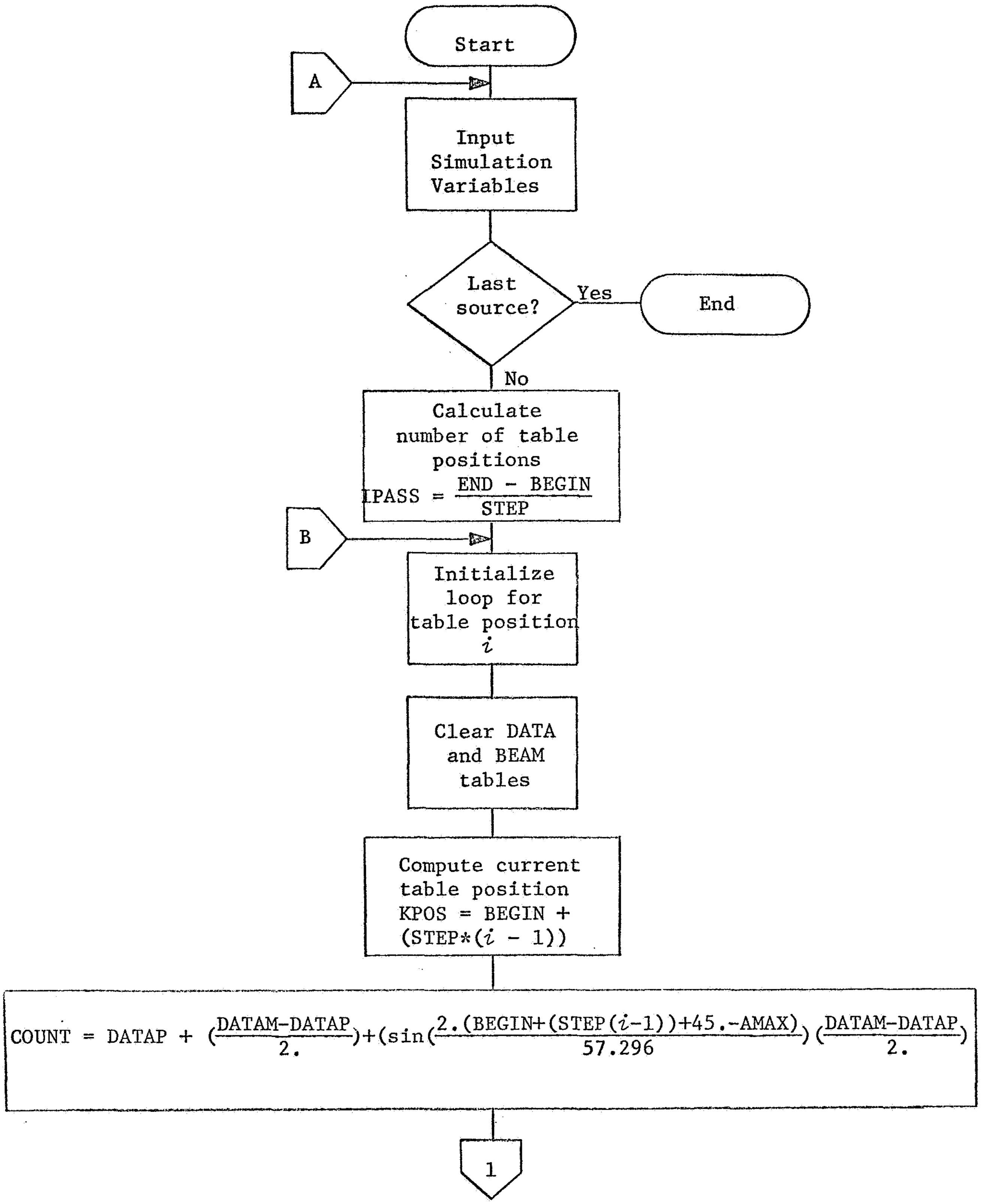


Figure 4-1. Data Generator Program

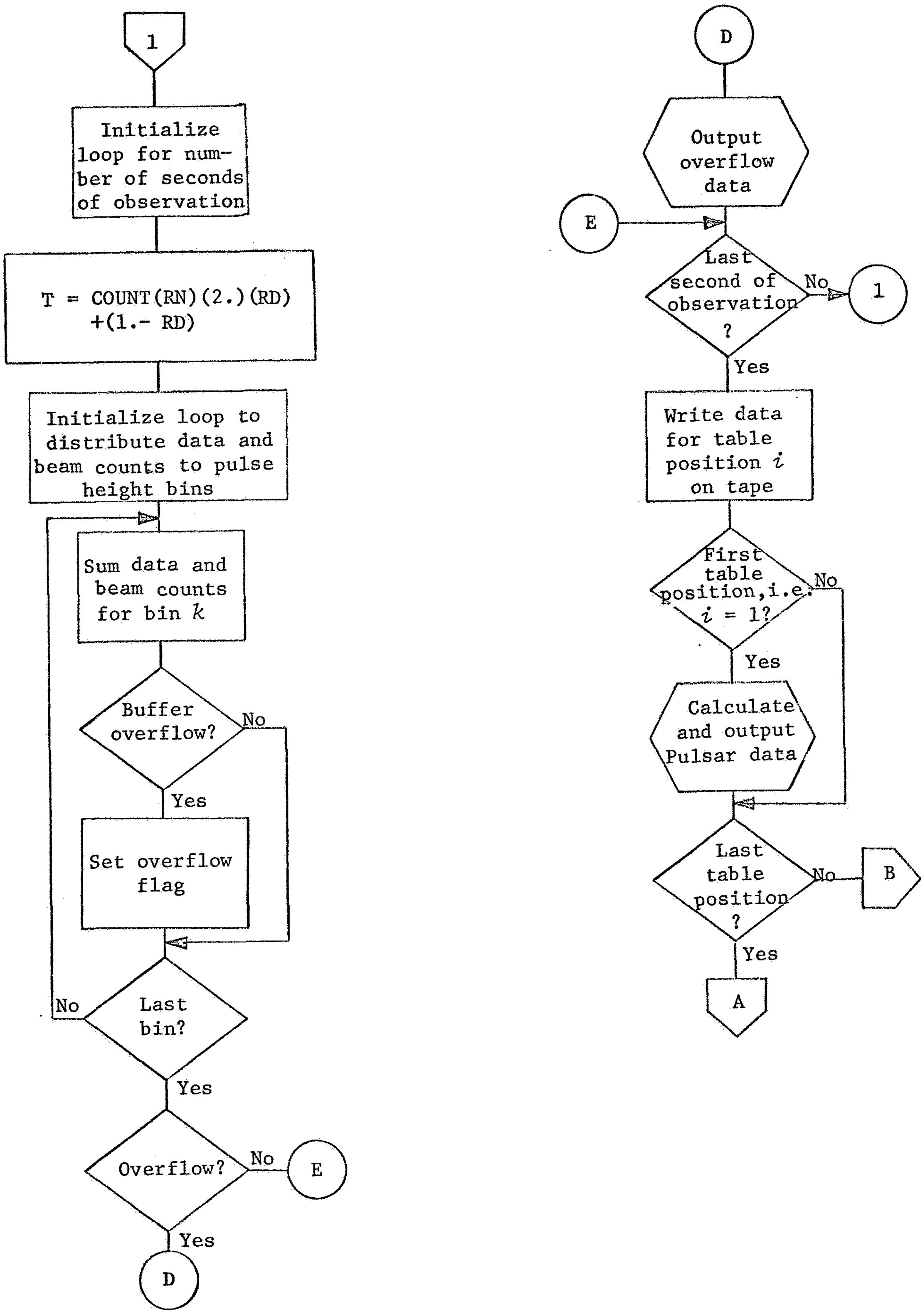


Figure 4-1. (Cont.) Data Generator Program

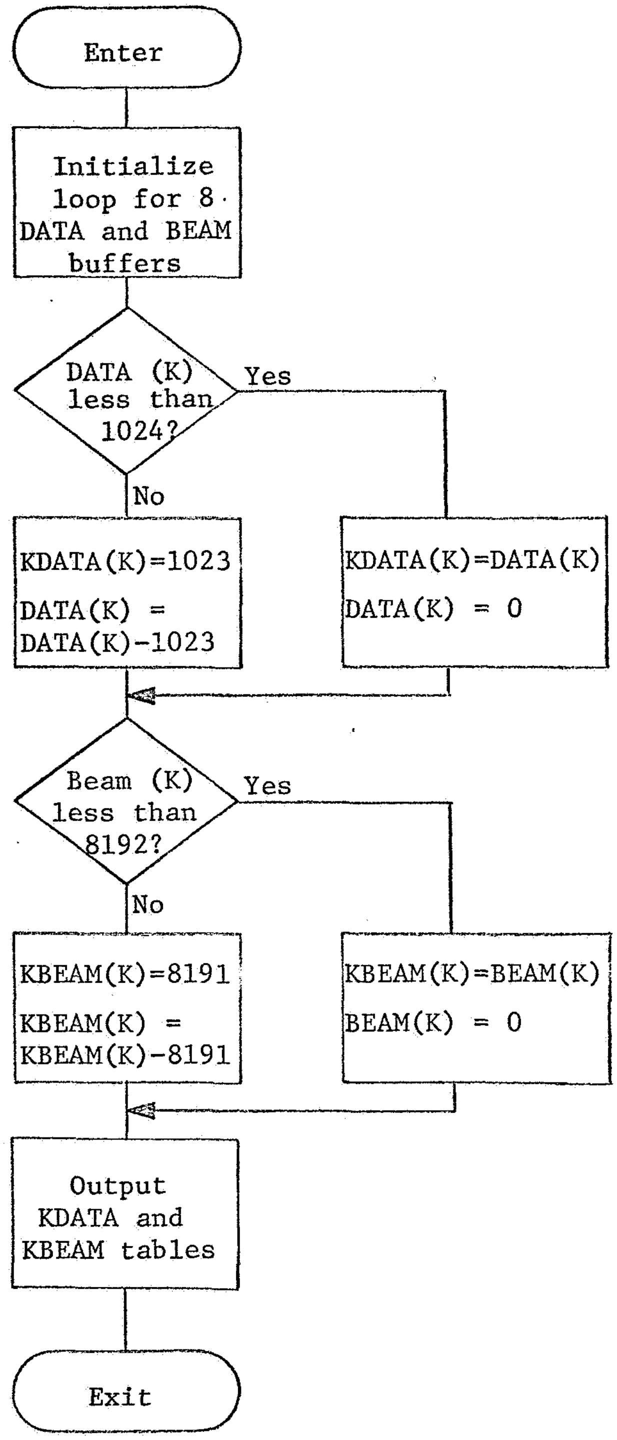


Figure 4-1. (Cont.) OVRFLO Subroutine

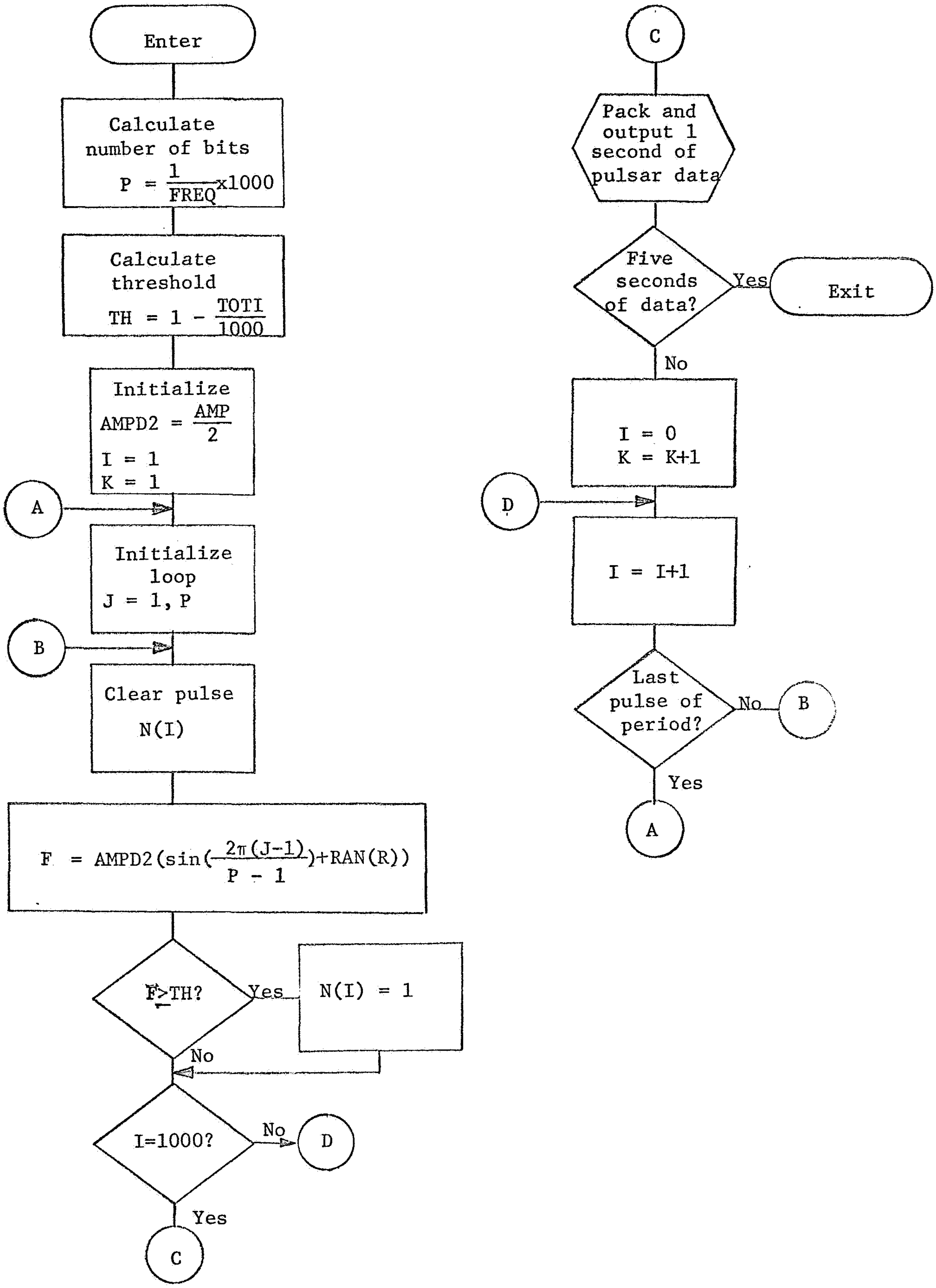


Figure 4-1. (Cont.) Pulsar Data Generation Subroutine

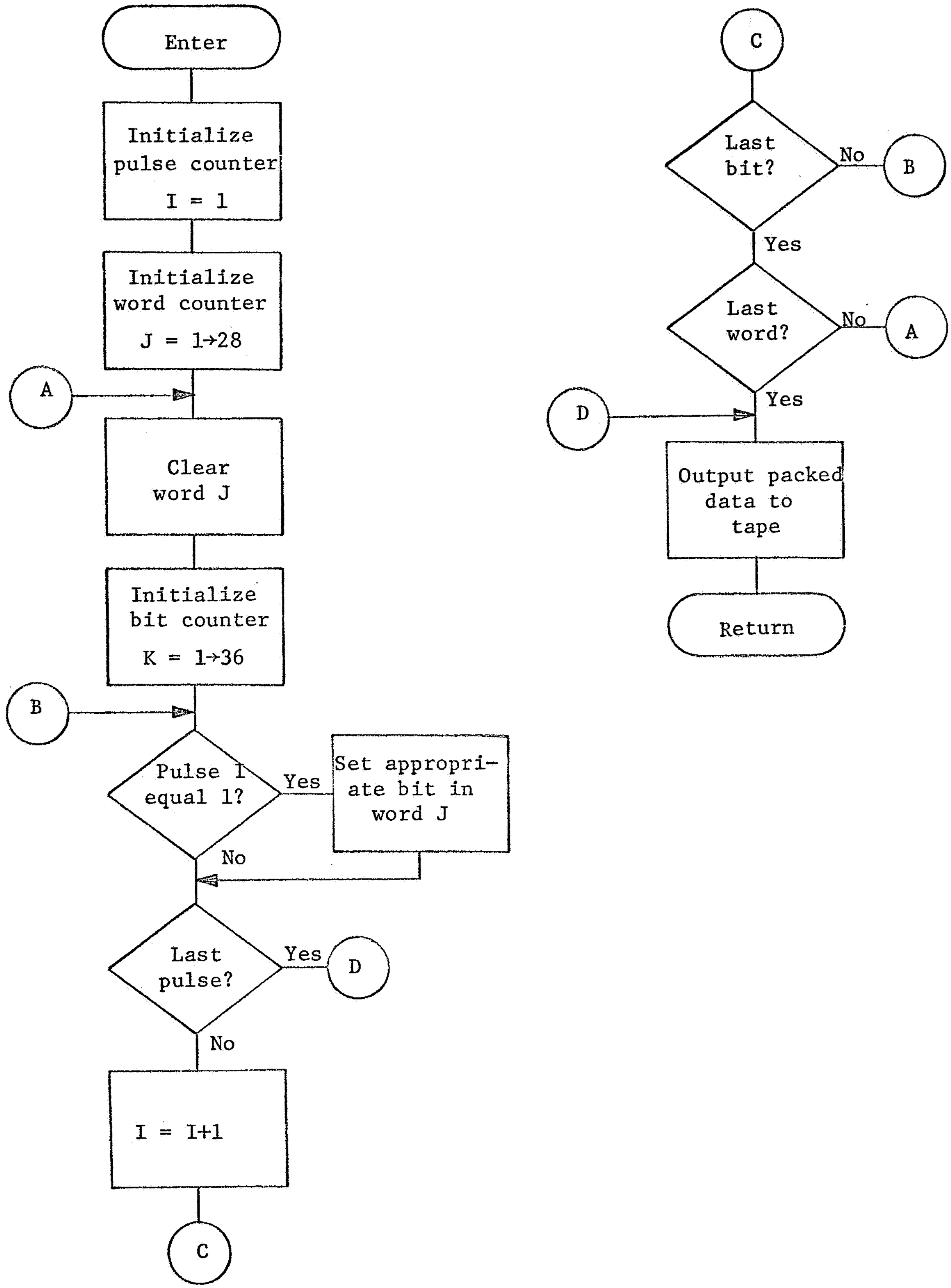


Figure 4-1. (Cont.) Pack Pulsar Data and Output to Tape Subroutine

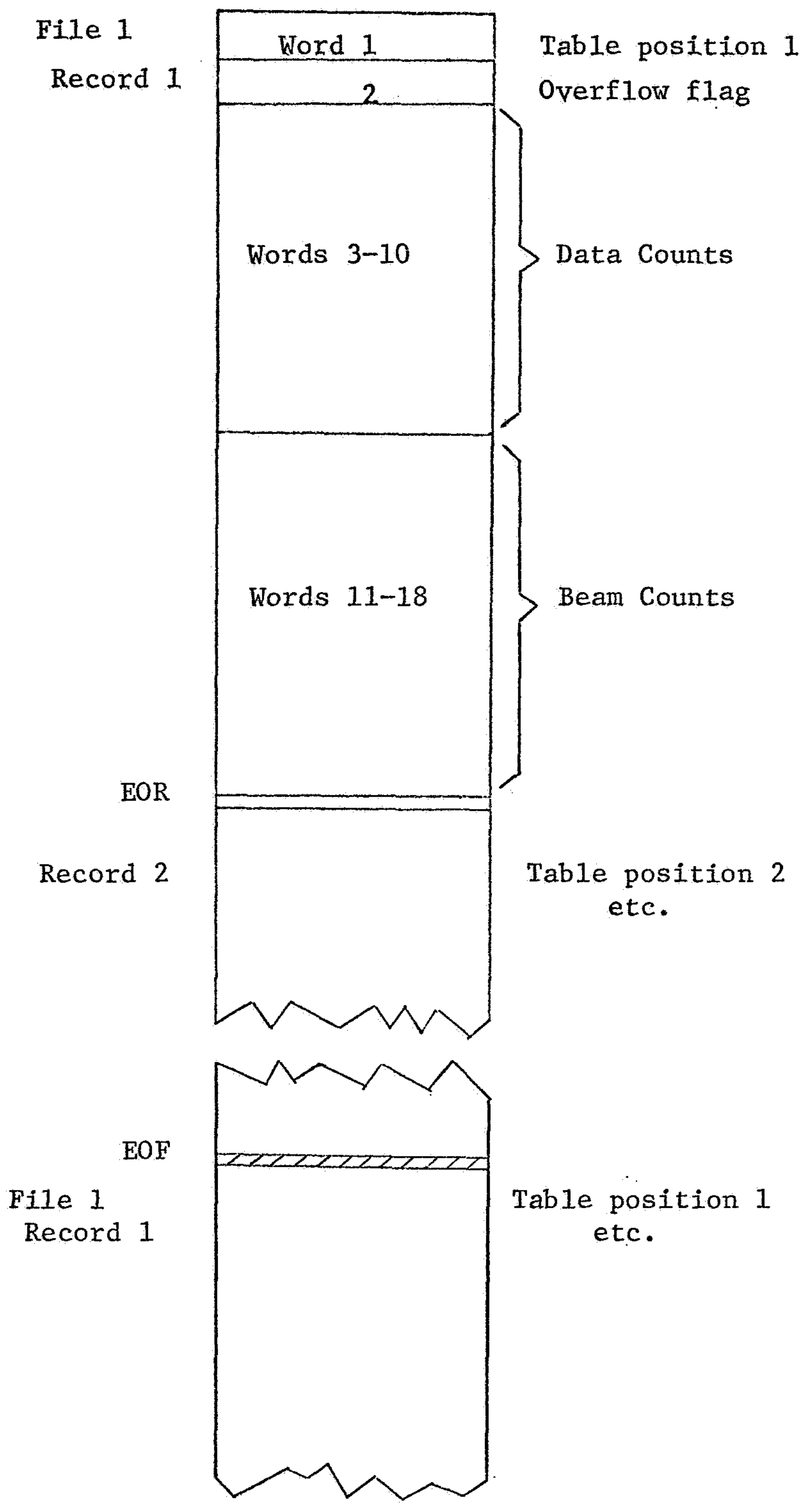


Figure 4-2. Simulated Polarimeter Data Tape Format

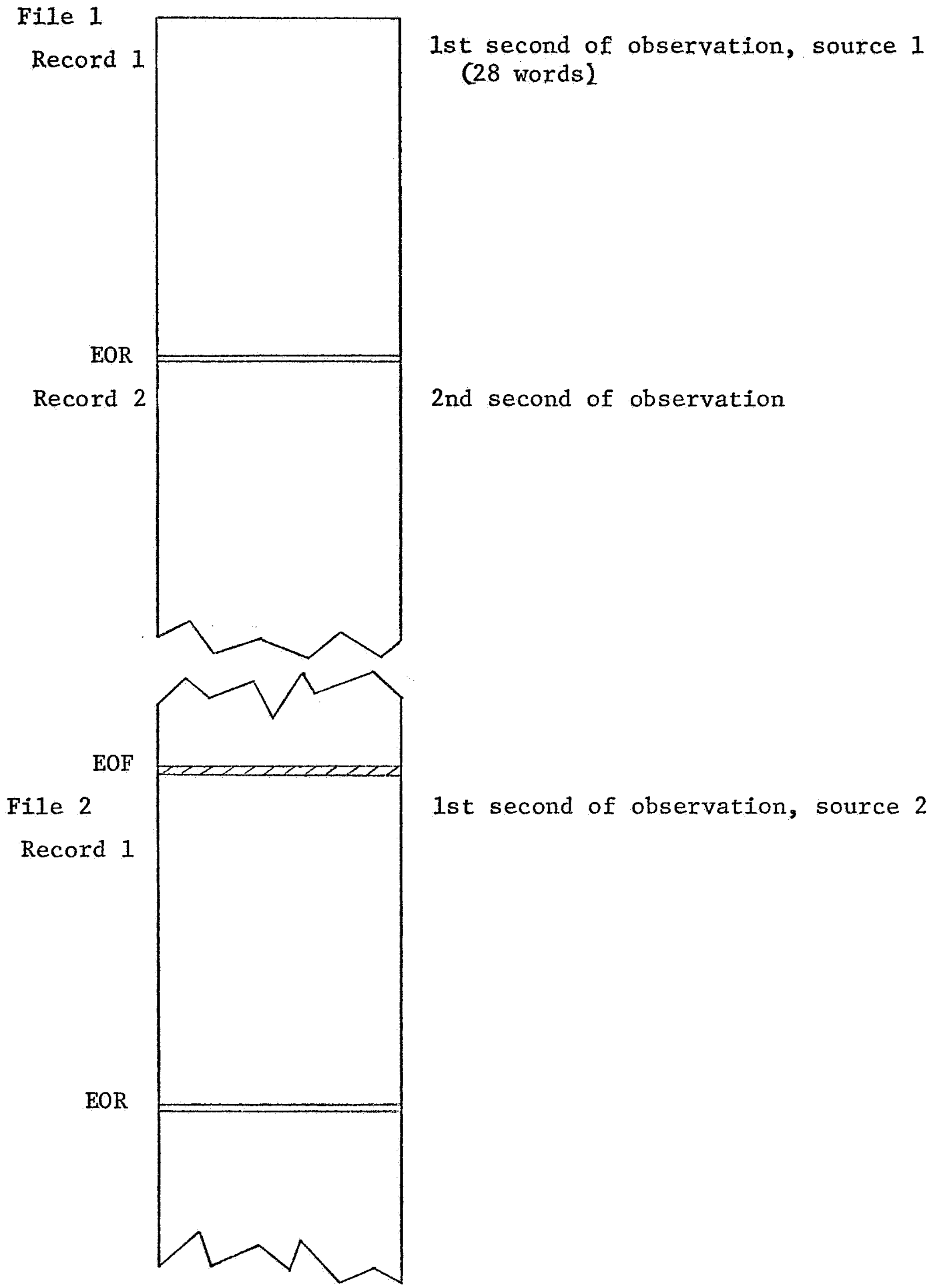


Figure 4-3. Simulated Pulsar Data Tape Format

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